

# RECORDS OF THE QUEEN VICTORIA MUSEUM, LAUNCESTON

## GEOLOGY OF THE DELORAINE-GOLDEN VALLEY AREA, TASMANIA

By

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### ABSTRACT

Seven thousand feet of isoclinally folded, eugeosynclinal, metamorphosed sediments and lavas of the Cambrian Dundas Group unconformably overlie the crenulated Precambrian Davey Group quartzites and schists. Asymmetrically folded rocks of the Ordovician Junee Group overlie the Dundas Group with an angular unconformity. The oldest formation is the Owen Conglomerate which is followed by the fossiliferous Caroline Creek Sandstone. The Gordon Limestone forms scattered inliers in Permian rocks. Eighteen hundred feet of gently dipping, fossiliferous Permian sediments are followed disconformably by 500 feet of Triassic sandstone. The Permian has an important oil shale seam near the base of the section but it has not been exploited. Jurassic dolerite has intruded the Permian and Triassic sediments in the form of sills and dykes. Late Mesozoic peneplanation, Tertiary faulting trending north-west, followed by out-pourings of basalt have together with a recent period of erosion combined to mould the present landscape, the topography having all the characteristics of youth.

### INTRODUCTION

The area (about 75 square miles) is to the south-east, and includes portion of, the agriculturally important Deloraine district. It is defined by the National grid co-ordinates 460,000 and 470,000 yards east and 870,000 and 890,000 yards north. Deloraine is on the Bass Highway and the North-West Coast railway. The Lake Highway commences from Deloraine and runs diagonally to the south-western corner of the area and, together with a branch road which runs from Golden Valley to Exton, provides ready access. The northern part of the area is developed agriculturally but the southern portion, especially the Cluan Tier region, is heavily timbered.

The horizontal control for the slotted template layout of the one mile to one inch maps were trigonometrical stations, the co-ordinates of which were supplied by courtesy of the Forestry Department.

The area was first examined by Reid (1924) who concentrated chiefly on the oil shale resources. A report was also made on the oil shale resources at Quamby Brook by Hills (1921).

Acknowledgments are made to the staff of the Geology Department, University of Tasmania, for their assistance during the compilation of this paper which was originally part of a thesis submitted for the degree of Bachelor of Science with Honours in February, 1954. The thesis was made available to J. B. A. McKellar, Hydro-Electric Commission, who extended the work to the south and south-west. His paper on these areas is published in the *Records of the Queen Victoria Museum*.

### PHYSIOGRAPHY

The northern part of the area is not more than 800 feet above sea level but Quamby Bluff, a peak standing out from the Great Western Tiers in the extreme southern section, rises to 4200 feet. The southern part has high relief.

Mechanical disintegration with periodic ice wedging is prevalent on the higher slopes of Quamby Bluff and Cluan Tier which have very little soil cover. Chemical weathering disintegrates the rocks of the lower areas, helped by the dense vegetation. The sandy soils derived from the Permian sediments are generally poor and contrast with the rich red clay soils developed on the Tertiary basalts. The alluvial soils of Stockers Plain, in the Quamby Brook Valley and bordering the Meander River near Deloraine, are agriculturally developed.

Springs are common in the Permian sediments and in the Tertiary basalts. In the latter, the site of the spring may be controlled by the junction of two flows where a scoriaceous bed acts as an aquifer. In the Permian sediments impermeable beds isolate the aquifer, so that each aquifer has its own independent water table. Springs have been formed above the impermeable limestone at the base of the Golden Valley Formation on the northern slopes of Quamby Bluff.

The drainage pattern is predominantly insequent where the streams traverse the Upper Palaeozoic, Mesozoic and Tertiary rocks. Elsewhere the major streams have been superimposed on the Lower Palaeozoic and Precambrian rocks, but some smaller streams are consequent on the structural trends. In the southern part of the area, streams are still high above base level and in their mountain tracts. The valleys are young and the rate of erosion is comparatively high. To the north the rivers are mostly in their plains tracts and the flow is considerably slower. Ox-bow lakes are common.

The present landscape has developed since the uplift after Permian and Triassic sedimentation. After injection of the Jurassic dolerite, erosion up to the Tertiary Period formed a peneplain on a dolerite surface. The peneplain was then broken by Tertiary block faulting. This caused rejuvenation of the upper reaches of the streams. The Pleistocene mountain glaciation has not been extensive enough to be recognisable in any form and probably merely assisted the erosive work of the streams. The latter gradually eroded their courses in the peneplain and were superimposed on the underlying older rocks. At the time of the outpourings of Tertiary basalts it is probable that, in general, the country immediately to the south was of greater altitude, this being necessary to account for the unconsolidated gravels which are commonly found on top of the basalt hills. The outpourings of the lavas do not appear to have radically altered the drainage system. Several cycles of erosion have affected the area, as indicated by entrenched meanders, interrupted profiles of streams, even crested mountain ridges and alluvial terraces. The cycle of river erosion is complicated by structural geology and the rock types present. The latter have produced streams that are practically at grade upstream from local base levels. In general the much dissected southern half of the area is in the youthful stage of the geomorphic cycle, but the northern half, which is composed predominantly of low rolling hills is in a later stage of youth in the same cycle.

## STRATIGRAPHY

### PRECAMBRIAN

#### Davey Group

The complex regionally metamorphosed rocks of the Davey Group (Carey, 1945) crop out as a ridge trending north-west, on either side of the Lake Highway from the 6-mile post to Golden Valley. It is composed of pure white massive quartzites, banded foliated quartzites and highly sheared and contorted quartz mica schists. These rock types are those typically found in the Davey Group as exposed elsewhere in Tasmania.

Transecting and ladder veins are common. The schistosity consistently strikes approximately 130°. The intricate structures and paucity of outcrops prevented any subdivision of the group. At a road junction on the Lake Highway (874,600N-463,900E) there is a good exposure of foliated and banded quartzites with numerous ramifying quartz veins and what appear to be "ghosts" of rounded pebbles.

### CAMBRIAN SYSTEM

#### Dundas Group

In this area the formations of the Dundas Group (Elliston, 1954) are as follows, in descending order:

	Thickness in feet
Scott Quartz Keratophyre ....	1200
Warner Siltstone .....	1900
Kentish Volcanics .....	1400
Thompson Formation .....	600
Calstock Formation .....	1900
<b>Total</b> .....	<b>7000</b>

Archer Formation ..... 900  
(Possibly facies equivalent of part or all of the above sequence)

The formations comprise a group of variegated, sheared, much jointed, uniformly steeply dipping, poorly sorted eugeosynclinal sediments which include greywacke, subgreywacke, greywacke conglomerate, siltstone, sandstone, slate and volcanic breccia and lava flows. They crop out in a large area around Quamby Brook township and in a narrow strip between the ridges of the Davey Group rocks and Owen Conglomerate near the Lake Highway.

#### Calstock Formation

The Calstock Formation is defined as a formation of subgreywacke and slate conformably underlying the Thompson Formation. The base of the formation is not visible. The type area is at 877,000N-464,950E.

The formation comprises dark-brown to orange-brown slate, mottled pink and white coarse subgreywacke and pink to orange siltstone and sandstone. The formation exhibits extremes of lithology in very short distances.

The sheared subgreywacke is composed predominantly of subrounded, ellipsoidal chert grains and is exposed in a quarry at 878,350N-464,250E. It has been silicified and in section many pebbles show an outer annulus of fine silica with an unaltered core. The chert is grey to black in colour and shows a remarkable range in grain size, the largest grains being 2 cm. across. Some chocolate-brown clay pellets are present and together with quartzite and quartz mica schist fragments, comprise about 3 per cent of the rock. The matrix is dark-brown and composed of fine quartz and sericite.

The siltstone exhibits rhythmic graded bedding and contains angular quartz and minor quartzite with a matrix of clay and fine quartz. A clay pellet or intraformational conglomerate contains disc-shaped, elongated, angular clay fragments, up to 2 cm. in diameter set in a grey-green matrix.

TABLE I

## FIELD RECOGNITION AND DATA OF THE FORMATIONS OF THE DUNDAS GROUP

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Type of Evidence	Calstock Formation	Thompson Formation	Kentish Volcanics	Scott Quartz Keratophyre	Warner Siltstone	Archer Formation
FRESH ROCK	Brown to orange-brown slate. Pink and pale grey sub-greywackes with chert and clay fragments.	Blue-green slate and dark-green greywacke and greywacke conglomerate. Greywacke contains fragments of spilite, chert, quartzite, angular quartz, hornblende, feldspar and muscovite.	Dark-green splite, light-green volcanic breccia.	Usually pink with some green chloritic phases.	Yellow-brown to orange siltstone. Minor grey sub-greywacke.	Dense black slate. Blue-grey and mottled black and white sub-greywacke which contains angular quartz and bent muscovite flakes together with quartzite, schist and slate fragments.
WEATHERED ROCK	Slate weathers to orange-brown with pink topsoil.	Grey-green and brown.	Grey green.	Pale pink, bleached appearance.	Pink to orange	Pale grey. Slate does not weather noticeably.
METAMORPHISM AND ALTERATION	Highly sheared in places. Numerous joint planes. Silicified.	Small faults, slight shearing.	Highly altered, sheared, chloritised, and albitised epidotised.	Slightly sheared, extensive albitisation and devitrification, some chloritisation.	Cleaved but relatively unaltered.	Slightly sheared and cleaved.
STRUCTURE AND TEXTURE	Graded bedding.	Graded bedding and slump structures.	Porphyritic with some chilled phases. Quartz epidote and chrysotile veins.	Porphyritic with some chilled phases. Pink phenocrysts of plagioclase and clear quartz in fine grained pink groundmass.	Laminated with graded and rhythmic bedding. More uniform sequence.	Rhythmic bedding of slate and sub-greywacke.
PHYSGEOGRAPHY	No distinctive form. Low hills.	Sharp low linear ridges.	No distinctive form, low sharp outcrops.	Low rounded hills.	Crops out in Creek beds and forms low hills—no distinctive form.	Harder sub-greywacke forms ridges, slate so-ter and crop out in creek beds.

The fragments vary greatly in size and shape and are mostly circular, but others are ellipsoidal and biconvex. The clay is pleochroic and contains some fine angular quartz. The matrix has subangular quartz and brown clay. The rock probably represents a desiccated clay lamina which was subsequently recemented.

From a disaggregated specimen of subgreywacke from this formation, 1.21 per cent heavy minerals were separated. A size analysis demonstrated the very poor sorting of the rock, 76 per cent of the grains lying between 0.149 and 1.003 mm. and 15 per cent of the grains being less than 0.074 mm. in diameter.

#### Thompson Formation

The Thompson Formation is defined as the slate and greywacke conformably overlain by the Warner Siltstone and conformably overlying the Calstock Formation. The type area is at Quamby Brook (876,050N-465,240E).

The formation comprises fine hard blue-grey slate, subgreywacke slate and poorly sorted blue-green to dark-blue calcareous greywacke with subordinate greywacke conglomerate and occasional beds of subgreywacke. The rocks vary considerably in lithology both through the section and along the strike.

The green slate contains traces of sulphides, mostly pyrrhotite. It is almost identical in composition to the subgreywacke slate except that minor amounts of feldspar are present and rock fragments are absent. The quartz particles have an average diameter of about 0.04 mm. The subgreywacke slate contains angular quartz of average diameter 0.01 mm. with muscovite, hornblende, quartzite and chert fragments, and a minor amount of epidote. The matrix is greenish-brown in colour.

The greywacke contains angular fragments of chloritised basic lava which are identical with the Kentish Volcanics. It is light grey-green in colour (exceptionally almost black) and massive. Some are dense fine-grained rocks but others have rock fragments up to 3 mm. in diameter. Subangular to angular quartz is present together with abundant subrounded rock fragments consisting of chert, quartzite, quartz mica schist, spilite and slate. Approximately 10 per cent feldspar and hornblende is present together with minor amounts of calcite, epidote, muscovite, magnetite, chlorite and leucoxene. The hornblende is in the form of subangular, roughly tabular grains, sometimes bent and up to 0.4 mm. long.

The greywacke conglomerate outcropping at 880,075N-463,900E shows rounded pebbles of dark-green spilite, large aggregates of white calcareous material and occasionally fragments of slate, quartzite and subgreywacke. The pebbles range up to 8 cm. in diameter. The rock may represent a re-worked volcanic breccia and is partly tuffaceous as several small, glassy fragments were seen. The rock is chloritised and slightly sheared and often the matrix is indistinguishable from the grains. Where the former is distinguishable, it contains angular quartz up to 0.4 diameter, chert, sericite, epidote, chlorite, hornblende and leucoxene. In general the rock is dark-green in colour.

The minor subgreywackes are hard, dark-green rocks exhibiting rhythmic bedding. They are characterised by sparkling mica flakes and are often

highly calcareous. Slump structures are present. Angular quartz with muscovite, chlorite, calcite and hornblende are the chief constituents with rock fragments sometimes almost as abundant as the quartz. The calcite is present as large granular aggregates and irregular interstitial masses and is probably secondary in origin.

#### Scott Quartz Keratophyre

The Scott Quartz Keratophyre is defined as the formation conformably overlying the Warner Siltstone. The top of the formation is concealed by the overlying unconformable Quamby Conglomerate and it may interfinger with the Warner Siltstone. The type locality is at 882,650N-460,650E.

Macroscopically the rock is massive, flesh-pink to pinkish-brown, the colour being due to the abundant feldspar. The euhedral feldspar phenocrysts average 3 mm. in length. Few large irregular masses of dark-green secondary chlorite and small clusters of pyrite crystals are present. Some specimens show a dark-green matrix with clear glassy anhedral quartz phenocrysts, and pink, stout euhedral rectangular laths of feldspar.

The rock varies considerably in texture and grain size, but microscopically the composition is relatively constant. Albite (Ab, An) is the chief mineral constituent (60%); with quartz (25%), perthite (2%), biotite (10%), chlorite (2%), iron oxides and sulphides (1%). The formation could equally well be an acid extrusive, possibly a rhyolite or a sill. In places there is some semblance of a flow structure and homogeneous microcrystalline portions are present which may represent chilled margins, but no contacts with the underlying formation were visible. Irregular joints are common but there are no distinctive traceable lineaments that could represent the junction of flows.

A keratophyre tuff was found about ½-mile north-east of Quamby Brook township. It is a dense sheared rock with a dark-green chloritised matrix. It contains fragments of white feldspar, clear quartz up to 5 mm. in diameter, quartzite and chert. Incomplete crystal outlines are still preserved on the large grains of feldspar which are considerably altered to sericite.

#### Kentish Volcanics

The Kentish Volcanics are defined as the formation of basic lavas and associated pyroclastics interfingering with the Warner Siltstone. The type locality is at Quamby Brook (874,000N-465,950E).

The formation comprises dark to light-green sheared chloritised and epidotised spilite and volcanic breccia, the latter showing large angular chloritised fragments of spilite. Occasionally pyrogenetic crystals of white plagioclase are visible in the spilite, and chlorite and epidote-quartz veins commonly traverse the rock. No contacts of the lava with the country rock or structures common to lava flows are present because of the shearing and alteration the rock has undergone. The breccia indicates explosive vulcanism. To the north-west beyond a point roughly at 877,740N-462,950E the lavas and breccias are absent; this probably indicates the margin of the flow.

The spilite is composed predominantly of albite, oligoclase (50%), epidote (15%), chlorite (20%), quartz (5%), and pyroxene (5%), with magnetite, perthite, leucoxene, sericite and limonitic material composing 5 per cent of the rock. Phenocrysts

of feldspar and a little pyroxene are set in a dark-green matrix composed almost entirely of feldspar laths with interstitial chlorite and magnetite. Many of the laths have been bent, crushed and re-oriented and extensively sericitised. Deuteric or late magmatic epidote penetrates the laths along fractures and joints. The small quartz veins often show replacement borders. The rock is unusual in that it is porphyritic and shows no signs of being amygdaloidal. It represents a soda-rich basalt, the pyroxene being altered to chlorite and serpentine together with other abundant alteration products of pyrogenetic minerals.

The volcanic breccia consists mainly of angular fragments with some subrounded fragments. The fragments range up to 20 mm. in diameter and consist predominantly of spilitic altered to a mass of chlorite, calcite and epidote with remnants of feldspar and pyroxene. Rare chert grains are present. The matrix consists of dull-green chloritic materials, epidote and disintegrated feldspar grains.

### Warner Siltstone

The Warner Siltstone is defined as the formation of siltstone with subordinate slate and subgreywacke lying conformably between the Archer Formation above and the Thompson Formation below. It is transgressive and overlies the Davey Group with an angular unconformity. The type area is on the Hamby Brook road about 3 miles south-east from Deloraine (1,800N-462,930E). Nowhere is there a complete uninterrupted sequence.

The formation consists predominantly of laminated soft rhythmically bedded pink to red-brown siltstone with interbedded well-jointed green-brown slate and some laminae of hard blue-grey slate. A coarse subgreywacke near the centre of the formation is a good marker horizon in this formation on the south-western limb of the anticline and is probably contemporaneous with a coarser subgreywacke outcropping along the south-western margin of the Scott Quartz Keratophyre. Petrographically the subgreywacke contains angular quartz averaging 0.04 mm. in diameter and rock fragments, quartzite, some quartz mica schist and chert. Few bent muscovite flakes are present. In the hand specimen few rounded quartzite pebbles up to 5 mm. across are visible.

A slide of the siltstones shows pink laminae of coarse-grained silt alternating with finer dark grey-brown laminae; gradation between the two is common. The laminae vary from a fraction of a millimetre to 4 mm. thick. The quartz grains throughout are angular; they average 0.02 mm. in diameter in the finer-grained laminae and 0.05 mm. in the coarser laminae. Sericite and clay minerals increase in proportion in the finer laminae. Muscovite flakes are present throughout, but are not always parallel to the lamination planes.

### Archer Formation

The Archer Formation consists of subgreywacke and slate with subordinate greywacke and greywacke breccia. It is defined as the formation conformably overlying the Warner Siltstone and rests with angular unconformity against the Davey Group rocks. The formation is exposed at only one locality (874,780N-464,320E).

The uppermost beds are very coarse with angular fragments up to 5 cm. in diameter together with rare well-rounded quartz pebbles. Pyritic slate is predominant near the base of the formation. The formation was not found outcropping on the margin

of the Davey Group rocks to the north-west. It may be equivalent to all or part of the Dundas Group.

The subgreywacke is flaggy, hard and blue-grey where fresh. In thin section it consists of large angular fragments of the metamorphic variety of quartz (75%) showing graphic intergrowth, rock fragments (20%) including angular quartzite, quartz mica schist, dark-grey slate and many bent muscovite flakes (5%). The angular quartz grains of the matrix average 0.3 mm. in diameter. A few well-rounded quartz pebbles up to 2 cm. in diameter are present in the rock. Many of the subgreywacke specimens have a highly calcareous cement.

The greywacke contain up to 15 per cent feldspar not including the aggregates of feldspathic material composing the fragments. Chert, quartzite and quartz grains are also present with subordinate epidote, chlorite, calcite, magnetite and ferromagnesian minerals.

A thin section was cut of a specimen of rhythmically bedded siltstone from this formation. This shows alternating bands of sand and silt, the proportion of clay minerals being higher in the finer bands. In the coarser bands quartz and muscovite are present, the flakes of the latter not always parallel to the bedding planes. Some of the flakes are 0.2 mm. long, averaging about 0.05 mm. The quartz particles are about 0.04 mm. across with some up to 0.18 mm. but these are comparatively rare.

The proportion of sericitic material increases in the finer grades, the flakes being, on the average, 0.03 mm. long and 0.01 mm. wide. The quartz grains average about 0.02 mm. in diameter, the largest being 0.06 mm. Few opaque grains are present. A small amount of chloritic material is present but no feldspar grains were detected. A detailed microscopic analysis normal to the bedding is shown below in text figure I.

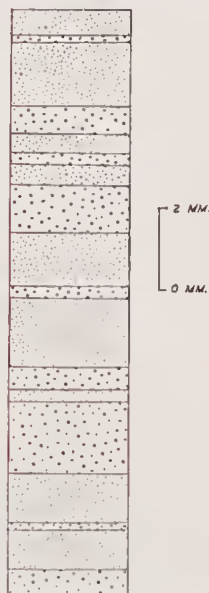


FIG. I.—Rhythmic alternation of coarse and fine bands in the Archer Subgreywacke and Slate.  
Scale: 5 millimetres = 1 inch.

This sequence shows the rhythmic bedding, but no major cycle is apparent. Gradation between the bands is common.

#### Discussion on Dundas Group

No fossils were found in rocks of the Dundas Group. They rest unconformably on the Precambrian Davey Group schists and are unconformably overlain by the Ordovician Junee Group and therefore correlated with similar eugeosynclinal Middle to Upper Cambrian rocks in Tasmania. The rocks indicate rapid deposition in shallow water with very little transportation of the sediments, and the vicinity of high mountain ranges. The absence of current bedding, the presence of coarse graded deposits, clay pellets, rapid textural variation and poor sorting indicate the loads were carried in suspension. The volume of sediment is too great to be accounted for by deposition in one season and the material must have accumulated and finally re-deposited in a graded bed at the present site. (See text figure II.) Turbidity currents of high

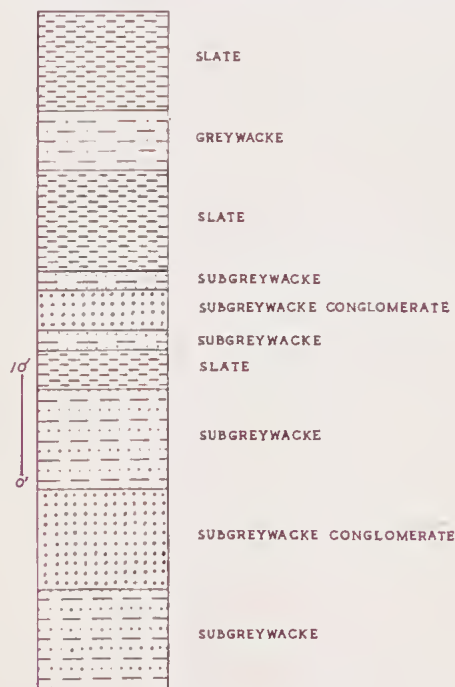


FIG. II.—Rhythmic alternation in the Archer Subgreywacke and Slate.

Scale: 20 feet = 1 inch.

density (Kuenen *et al*, 1950, 1952, 1953) explain many features of these deposits. The currents may be derived from the slump of material down a slope on which the sediment is deposited, earthquakes or storms causing the instability of the mass. In this way lutite can be deposited simultaneously with larger particles and may cover a very wide area. Very large blocks and unabraded clay fragments can be carried.

The classification of Tyrell (1933) adequately describes the greywackes common in the Dundas Group. Scott (1954) discusses the petrology of Cambrian volcanics similar to those found in this area.

#### ORDOVICIAN SYSTEM

##### Junee Group

The formations of the Junee Group in descending order are:—

	Thickness in feet
Gordon Limestone	1000
Caroline Creek Sandstone	1000
Owen Conglomerate	300

##### Owen Conglomerate

The Owen Conglomerate (Officer, Balfour and Hogg, 1895) crops out as two narrow ridges flanking the Lake Highway from the 6-mile post to Golden Valley and as a hogback 2-miles south of Deloraine. The formation consists of white to pink silicified oligomictic conglomerate with subrounded to rounded pebbles averaging 5 cm. in diameter, the maximum size seen being 16 cm. in diameter. The pebbles are predominantly quartzite with rare quartz mica schist and slate. The matrix is a medium-grained white sand but the silicification makes it impossible to separate the pebbles from the matrix. In thin section the grains have minutely irregular boundaries and the silicification has produced a graphic intergrowth of quartz in the matrix.

The conglomerate is interbedded with silicified, flaggy pink to white sandstone which is predominant near the top of the formation. Tubicolar annelid casts, cf. *Seolithus*, occur in the sandstone of the most northerly exposure. A deeply weathered profile of the conglomerate is present at 883,000N-461,260E. Here a pebble showing blue kyanite and golden-brown mica in a quartzite was found.

The thickness of the formation is about 300 feet and is probably a shallow marine deposit at the base of cliffs of Precambrian quartzite. Outcrops of the conglomerate appear to be thicker on the flanks of these basal rocks. The Owen Conglomerate is Tremadocian assuming that it is synchronous throughout the State.

##### Caroline Creek Sandstone

The Caroline Creek Sandstone (Caroline Creek beds of Etheridge, 1883) outcrops on Stockers Plain where it conformably overlies the Owen Conglomerate and is conformably overlain by the Gordon Limestone. It consists of approximately 1000 feet of amber to pale-yellow, friable, porous sandstone but in places is silicified and flaggy. It is well sorted with subrounded quartz grains and few muscovite flakes. It is fossiliferous and contains cephalopods, gastropods and *Tritoechia careyi* Brown, a brachiopod so far recorded only from the Florentine Valley Mudstone. The genus is restricted to the Lower Ordovician.

### Gordon Limestone

Only two small exposures of limestone correlated with the Gordon Limestone (Gordon Limestone of Gould, 1866) are present. One outcrops on the eastern extremity of Stockers Plain (874-560N-463,120E) where it conformably overlies the Caroline Creek Sandstone and is overlain unconformably by Permian rocks to the south-east. It also outcrops on Cameron's property (460,470N-464,460E) but no contacts with surrounding rocks are visible. The limestone has been quarried at both sites. The minimum thickness of the formation is about 1000 feet.

The limestone at Stockers Plain is light blue-grey, sheared, foliated and crenulated. The rock is schistose and is cut by small faults and calcite veins up to 10 cm. wide. The calcite is parallel to the bedding and occasionally forms lensoid bodies. A slice of the rock shows indistinct fossils with echinoderm plates and cross sections of trilobite exoskeletons. The etched surface of the rock showed a doubtful bryozoan and several ostracods. About 3 per cent detrital angular quartz is visible and stylolites are common. The cement of the limestone is partly bituminous and an unsaturated tarry residue was extracted with xylene. Several sink holes are present on Stockers Plain north-west of the quarry, undoubtedly formed in this limestone.

The limestone from Cameron's property exhibits ramifying calcite veins, stylolites and slickensided surfaces. The rock is almost black in colour.

The Gordon Limestone was deposited in shallow seas bordered by low-lying land surfaces from which very little clastic material was derived. The trilobite and crinoid remains suggest deposition near the centre of the continental shelf where these forms would normally abound. By lithological correlation and stratigraphic position it is assigned an Upper Ordovician age.

### PERMIAN SYSTEM

The Permian sediments are confined to the southern portion of the area where they are protected from erosion by sills of Jurassic dolerite. The total thickness of the System at Quamby Bluff is 1830 feet. Several facies occur in some of the formations in the System. The formations in the type section measured on the northern slopes of Quamby Bluff are as follows, in descending order:—

	Thickness In feet
Ferntree Mudstone .....	650
Woodbridge Formation .....	335
Liffey Sandstone .....	250
Golden Valley Formation .....	200
Quamby Mudstone .....	350
Stocker's Tillite .....	45

This section is presented in detail as a columnar section in text figure III.

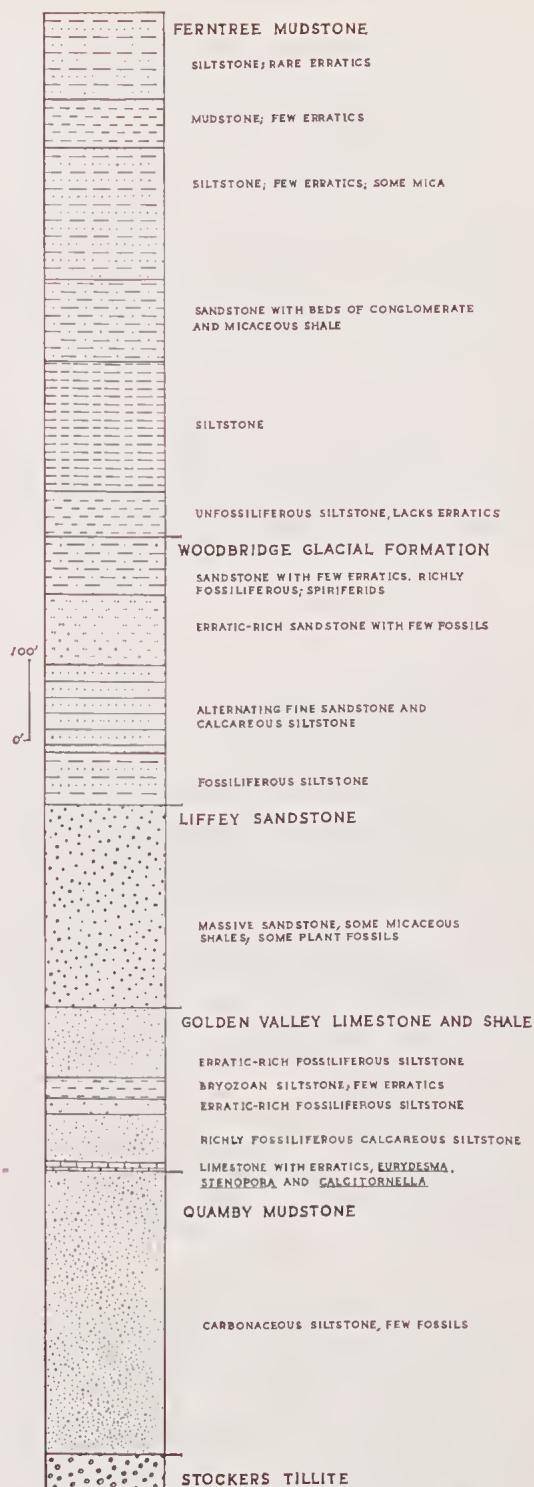


FIG. III.—Summary of the Permian stratigraphy at Golden Valley.

Scale: 250 feet = 1 inch.

### Stocker's Tillite

The Stocker's Tillite is defined as the basal formation of the Permian System overlying the Junee Group unconformably and overlain conformably by the Quamby Mudstone. The type locality is at the south-eastern extension of Stocker's Plain (co-ordinates 874.5N-646.3E).

It is a coarse, poorly sorted, unfossiliferous rudite with a calcareous cement. It is grey-brown with subangular to subrounded and rarely rounded boulders up to 25 cm. in diameter but varying greatly in size. The boulders are composed chiefly of the underlying Gordon Limestone, some quartz, quartzite, quartz schist and slate and compose 20 per cent of the rock. They are set in a fine matrix of quartz, clay and calcite. The surface of the boulders are frosted and dull but no striated surfaces were found. The properties of the rock agree with the salient features of glacial till given by Pettijohn (1949). The formation is 45 feet thick and grades imperceptibly into the Quamby Mudstone. The formation may be correlated with the basal glaciation formation common to the Permian System at many localities in Northern Tasmania.

### Quamby Mudstone

The Quamby Mudstone is defined as the formation lying conformably between the Stocker's Tillite below and the Golden Valley Formation above on the northern slopes of Quamby Bluff (co-ordinates 874.5N-463E).

The rock is a blue-grey mudstone with occasional dark-grey carbonaceous bands. It is flaggy and prone to spheroidal weathering. Rounded pebbles of quartz, quartzite and black chert up to 3 cm. in diameter are sparsely distributed through the mudstone. A few unidentifiable fossil fragments are present and the cement is partly calcareous. The formation is 350 feet thick and may be coeval with the lower part of the Inglis Stage of the Preolenna sequence and the lower part of the Achilles Stage of the Mt. Pelion section.

### Golden Valley Formation

The Golden Valley Formation is defined as the formation lying conformably between the Quamby Mudstone below and the Liffey Sandstone above. It is 200 feet thick and consists of richly fossiliferous limestone, calcareous siltstone, shale and fine sandstone. This formation is named after Golden Valley in which it occurs. The type area has the co-ordinates 874N-463.9E.

The basal massive coquina limestone, which is up to 20 feet thick, contains abundant erratics of quartz, quartzite and banded schist up to 30 cm. in diameter and abundant spiriferids, fenestellids, gastropods and pelecypods. It contains a small amount of detrital quartz, the organic remains and calcite cement comprising about 60 per cent of the rock. Secondary quartz as radiating spherulites of chalcidony compose about 15 per cent of the rock and the remainder is made up of rock fragments. The limestone is allochthonous in origin.

The limestone grades upwards into light-brown calcareous, fossiliferous shales with abundant fenestellids. Erratics are still abundant. The top beds are coarser, poorly sorted shale and fine sandstone, pale-grey and blue-grey in colour, light-brown and yellow on weathered surfaces. Rare large erratics are present and fossils plentiful.

Fossils from the formation, determined by Banks include—*Dellopecten limaciformis*?, *Spirifer avicula*?, *Martiniopsis subradiata*, *Martiniopsis oviformis*, *Platyschisma ceula*, *Eurydesma cordatum*, *Euomphalus*, *Stenopora tasmaniensis*?, *Aviculopecten*, *Polypora*, and the foraminifera *Calcitornella stephensi*. The latter indicates correlation with the Darlington Limestone (Banks, 1957) at Karoola, Maria Island, Woody Island and in several places in the Hobart area. The formation was deposited in a shallow sea and the abundant erratics indicate the presence of continental glaciers on neighbouring land surfaces.

### Liffey Sandstone

The Liffey Sandstone is defined as the formation which lies conformably between the Woodbridge Formation above and the Golden Valley Formation below. This formation is named after the Liffey River on which it outcrops. The type area for the formation is, however, on and beside the Glencoe Road, Golden Valley, with the co-ordinates 873.5N-463.7E.

The formation is 250 feet thick and consists of pale-brown and rarely pink massive sandstone with sparkling quartz and some interbedded micaceous shale. It is cross-bedded and has rare limonite concretions. Some thin carbonaceous laminae and plant remains may indicate fresh water deposition. A thin section shows subrounded quartz grains and some quartzite and quartz mica schist. The grains are tightly packed and the total volume of cement is less than 3 per cent. A sample of the sandstone contained 0.39 per cent heavy minerals and 40 per cent of these were magnetite, the remainder being ilmenite and hematite. The formation may correspond to the sandstone enclosing the Mt. Pelion Coal Measures.

### Woodbridge Formation

The Woodbridge Formation (Prider, 1948) is 335 feet thick and lies conformably between the Liffey Sandstone below and the Ferntree Mudstone above. It consists of poorly sorted shaly and flaggy, fine to coarse, grey-brown and yellow lutites and interbedded fine arenites. Erratics are abundant in restricted horizons including subangular to subrounded ellipsoidal quartzite, mica schist and slate pebbles. The quartz grains are subangular to angular and the abundant matrix is composed of rock flour and clay but is occasionally calcareous. Occasional grains of fresh feldspar, mostly the acid variety of plagioclase are present.

A richly fossiliferous bed 50 feet from the top of the formation is a medium-grained arenite with occasional erratics and is a good marker horizon.

Fossils from this bed, determined by Banks include, *Dielasma hastata*, *Martiniopsis oviformis*, *Martiniopsis subradiata*, *Platyschisma ocula* and *Spirifer vespertilio*?

The formation was deposited in a shallow sea with an adjacent low glaciated shore line.

### Ferntree Mudstone

The Ferntree Mudstone (Ferntree Mudstones of Carey and Henderson, 1945) is 650 feet thick. It overlies the Woodbridge Formation conformably and is disconformably overlain by the Triassic sandstone and shale. The formation consists of siltstone, mudstone, argillite and sandstone, in which so far no fossils have been found. There are several minor poorly sorted beds rich in angular erratics, but otherwise only sparse large erratics are found. A siliceous cement is present in the coarser arenites but in the lutites it is argillaceous. The latter have an isotropic fabric and are blue-grey, brown and sometimes black when unweathered. The weathered rock is invariably cream-coloured. Bedding is both shaly and flaggy. The hard argillites contain up to 7 per cent angular quartz averaging 0.01 mm. in diameter, with subordinate rock fragments, muscovite, magnetite, and up to 3 per cent feldspar. The matrix consists of clay, chlorite grains and rock flour.

Three hundred and twenty feet from the base of the formation there is a massive, siliceous sandstone member 165 feet thick which contains beds of ill-sorted round and discoidal pebbles chiefly of quartz and quartzite. The sandstone contains angular quartz and is poorly sorted. It is resistant to weathering and stands out as a prominent ledge on the hill slopes. Although it does not contain a high percentage of feldspar it is lithologically similar to the Risdon Sandstone.

The formation was deposited under conditions unsuitable for marine life but where carbonaceous matter, which is responsible for the colour of the argillites, could accumulate. Incursions of glaciers on neighbouring land surfaces produced the beds rich in erratics.

### PERMIAN SYSTEM IN ADJACENT SECTIONS

The base of the Permian System at the south end of the Quamby Brook Valley crops out at 874,260N-465,720E. The Stockers Tillite is absent and the Quamby Mudstone is 532 feet thick. The Bakes Oil Shale Member which is 5 feet thick occurs 65 feet from the base of the Quamby Mudstone. The oil shale has angular quartz of 0.025 mm. average diameter, and subordinate rock fragments, magnetite, sericite and traces of calcite and feldspar. In place the abundant circular spore cases average 0.4 mm. in diameter. The Golden Valley Formation forms a distinct ridge on the surrounding hills and is overlain by a dolerite sill. Incomplete sections of the Lifey Sandstone overlying the Golden Valley Formation are occasionally present beneath the sill. This section is presented in columnar form as text figure IV.

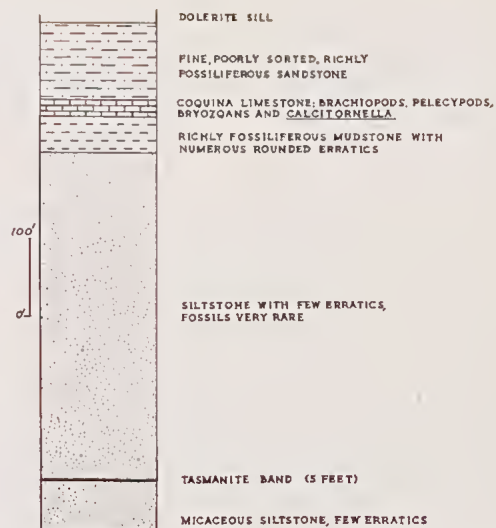


FIG. IV.—Summary of the Permian section at Quamby Brook.

Scale: 250 feet = 1 inch.

In the southern part of the area on the Lifey Road there are fossiliferous interbedded shales and tillite mudstone and sandstone of the Woodbridge Formation. The grey-brown, poorly sorted, richly fossiliferous sandstone 50 feet from the top of the formation is easily recognized here. This formation is overlain by blue-grey and grey-brown lutite of the Ferntree Mudstone. A prominent bench of hard tillite sandstone about 200 feet above the top of the Woodbridge Formation occurs on the hill slopes to the west of the Lifey Road. It can be traced to the north and gradually swings west and crosses the Lake Highway at 870,530N-465,630E.

The limestone of the Golden Valley Formation is absent in the Permian section on the southwestern slopes of Quamby Bluff. The Lifey Sandstone forms conspicuous bluffs and the overlying sequence of Woodbridge Formation and Ferntree Mudstone presents a terraced appearance due to the alternation of sandstone and mudstone beds.

The Lifey Sandstone crops out in the "Early Rises" area and to the south-west is overlain by mudstone with erratics which probably represent the Woodbridge Formation. No fossils were found, however, and it was impossible to differentiate it from the overlying grey-blue mudstone underlying the Triassic sandstone.

Five hundred feet of the Ferntree Mudstone crop out at 880,850N-470,000E. The sediments consist of unfossiliferous grey mudstone and siltstone with few angular erratics and are overlain by Triassic sandstone.

Scattered boulders of Permian mudstone outcrop at 880,670N-464,920E. It is lithologically similar to the Ferntree Mudstone.

Voisey (1938) places the Tasmanite Stage above the Lower Latrobe Stage. It appears certain, however, that the Golden Valley Formation, the Lifey

Sandstone and the Woodbridge Formation are equivalent to the Lower Latrobe Stage, the freshwater Mersey Coal Measures and the Upper Latrobe Stage respectively. In this case the Tasmanite Stage is below the Lower Latrobe Stage. Recent work tends to disprove the correlation of the oil shale horizon with the Mersey Coal Measures and suggests that the Tasmanite Stage occurs 300-400 feet below the coal horizon.

### TRIASSIC SYSTEM

#### *Knocklofty Sandstone and Shale*

The friable sandstone and shale lying disconformably on the Permian sediments are correlated with the Knocklofty Sandstone and Shale (Knocklofty Sandstones of Johnston and Morton, 1890) on stratigraphic position and lithological similarity. The formation invariably crops out at the margin of the dolerite sills and the massive sandstones form steep cliffs on the northern slopes of Quamby Bluff. The contact with the Permian rocks is marked by a hard light-brown breccia bed which invariably marks the base of the Triassic System. The breccia contains subangular quartz and quartzite fragments up to 5 mm. in diameter with a siliceous isotropic cement.

The amber to pale-brown sandstone is massive, current-bedded, with rare thin fine conglomerate laminae, limonite concretions, and green and brown clay pellets. It contains subangular quartz grains (80%), about 10 per cent rock fragments, and few microlite, plagioclase and chlorite grains. The rock is well sorted and compacted. No fossils were found. Rarely the rock is an intense chocolate-brown.

The micaceous shale is prominent toward the top of the formation and has been injected by dolerite sills in many places. The shale is particularly susceptible to erosion. It is 100 feet thick and the underlying sandstone 400 feet. There is no evidence of the overlying feldspathic sandstone which is found in the Western Tiers.

Approximately 300 feet of the Knocklofty Sandstone and Shale underlie the dolerite 3 miles south-south-east of Exton and is 150 feet thick under the dolerite south of the Eden Rivulet. Scattered boulders of the basal breccia were found at both localities. On the south-western slopes of Quamby Bluff high bluffs of the massive sandstone are present and current bedding is well developed. The sets are generally 23 cm. wide, the laminae about 1 cm. thick, the top set laminae being absent.

A sample of the massive sandstone contained 0.198% heavy minerals which is considerably less than that found in the Liffey Sandstone. The minerals consisted of tourmaline, ilmenite, melanite and rare zircon. Only one or two grains of magnetic minerals were separated. A sample of shale from this formation contained only 0.027% heavy minerals.

### JURASSIC SYSTEM

#### *Dolerite*

The dolerite occurs as concordant and discordant sills and feeder dykes which cover about 30 per cent of the land surface within the area. It caps Quamby Bluff, Cluan Tier and the hills north of "Early Rises", "Ashley" and Exton. The Quamby sill is in the vicinity of 600 feet thick and the Cluan sill about 400 feet. The sills forming the lower lying hills in the central, eastern and northern sections are not much more than 200 feet thick. The depth of intrusion of the dolerite varied greatly. About 500 feet of Upper Triassic sandstone originally overlaid the Quamby sill and about 2000 feet of sediments overlaid some portions of the Cluan sill.

The dolerite is generally medium-grained, but the rock composing the dyke 250 feet wide that crosses the Lake Highway is very fine-grained. The latter variety is dark greenish-black but the normal massive variety is blue-grey. The contact of the dolerite with the underlying Triassic shale was seen at 871,380N-464,040E. The dolerite here is extremely fine-grained and exhibits remnants of plagioclase and augite altered to a mass of calcite and chlorite. Several quartz grains are incorporated in the dolerite but the underlying shale shows no visible hornfelsing. The contact is very irregular.

Vertical columnar jointing is common in dolerite cliffs of Quamby Bluff and, in a quarry 1½ miles north of Exton the closely spaced vertical jointing has imparted a laminated appearance to the rock. Sheaf-like, radiating zeolite is common in the joints.

The dolerite is undoubtedly synchronous with the widespread dolerite sills throughout the State.

### TERTIARY SYSTEM

#### *Ashley Basalt, Exton Member and Tertiary River Gravels.*

*The Ashley Basalt is defined as all those fine-grained basalts which occur in the area around Ashley (co-ordinates 886°N-463°E). The Exton member is defined as a flow of coarse-grained, porphyritic basalt which occurs about three-quarters of a mile south-east of Exton (co-ordinates 886°N-468°E). Both are Tertiary in age.*

Large outpourings of this volcanic rock are present in the northern half of the area. The total thickness of the flows is in the vicinity of 300 feet. The more common fine-grained, dense, dark blue-grey rock has been called the Ashley Basalt. There is evidence for a porphyritic, coarser-grained flow and this has been called the Exton Member which is left as remnants generally capping small hills. About ½-mile north of Deloraine on the Reedy Marsh road there is a cutting in the Ashley basalt showing a deeply weathered amygdaloidal capping. The amygdules are filled either with chabazite or a resinous amber clay which is probably nontronite. They are up to 15 mm. long and 6 mm. wide. The fresh greenish-black dense basalt contains phenocrysts of olivine, crystals of labradorite, augite and subordinate magnetite and nepheline. Olivine as small grains in the matrix is rare. Basalt from the Exton Member has rare large phenocrysts of olivine, the larger percentage being as smaller grains in the groundmass.

No tuffaceous deposits or signs of explosive vulcanism are associated with the basalt. To the north the basalt has overlapped the dolerite sill and to the south-west laps against the Owen Conglomerate.

In places a lateritic podsol has developed on the basalt and deposits up to 20 feet thick of pisolitic ironstone are present. Very large blocks of a highly siliceous conglomerate overlie this ironstone  $\frac{1}{2}$ -mile west-south-west of Exton. The boulders have a thin crust of ironstone attached and the soil of the surrounding hill slopes contains abundant rounded pebbles. The conglomerate may represent an interbasaltic gravel possibly silicified by overlying flows.

A restricted age cannot be assigned to the basalt but is correlated with Tertiary basalts elsewhere in Tasmania which in some places overlie Lower Tertiary leaf beds.

#### RECENT SERIES

Recent deposits include river alluvium and gravels, mountain rock flows and talus, and residual and local weathering products. The slopes of Quamby Bluff are covered with talus consisting of angular blocks of dolerite up to 20 feet across. Aided by the slope of the terrain, the weight of the blocks, and lubricated by the underlying clayey sediments, the talus has flowed down the mountain side. The leading margin of each flow has buckled up forming semicircular ridges up to 20 feet high and probably marks successive slumps of the material.

Residual deposits up to 20 feet thick occur on the Owen Conglomerate and have been quarried in several places. A bedded gravel deposit occurs in a quarry near the 11-mile post on the Lake Highway. The deposit has an initial dip of about 20° and is composed of angular fragments of Permian mudstone. It has formed from scree washed from the surrounding hill slopes.

#### STRUCTURAL GEOLOGY

Regionally, the area represents the site of sedimentation on the margin of the craton of Precambrian rocks, the Tyennan Block. Here the Dundas Group rocks are of great thickness and were deposited on the axis of the Porphyroid Anticlinorium (Carey, 1953). The Ordovician rocks (Junee Group) were laid down after the intervention of the Tyennan Orogeny, the Tyennan uplift probably occurring at the same time as Dundas sedimentation. The Tabberabberan Orogeny (Devonian) folded the Ordovician and older rocks and intense hydrothermal metamorphism and mineralization occurred in the Porphyroid Anticlinorium.

Hence, structurally, the area is dominated by the folded, steeply inclined Precambrian and Lower Palaeozoic rocks and the overlying Permian and Mesozoic rocks which exhibit only low regional dips. The rocks of the Davey Group which have been intensely squeezed with intricate drag folds, dip from 80° to vertical and strike to 310°.

An angular unconformity is interpreted between the Davey Group and the overlying Dundas Group. The latter is folded isoclinally with the beds generally dipping from 70-80° to the north-east. The structure is primarily an anticline which conforms with the structure of the overlying Owen Conglomerate. When compressed, relief was vertical; later north-south trending faults cut the fold. Assuming movement in the faults was vertical then the throw was very great. The horizontal displacement of the beds is 500 feet. The faulting probably occurred in the latter stages of the Tyennan Orogeny. The compression of the rocks has produced intense jointing and conjugate sets of joints symmetrically disposed about the axial surface of the fold are common. They can be considered as shear fractures which present their acute angle to the maximum stress and indicate relief in a horizontal direction.

The Scott Quartz Keratophyre and Kentish Spillite both occur as formations interfingering with the Warner Siltstone. The quartz keratophyre, however, occurs 600 feet higher in the sequence than the Kentish Spillite and, therefore, is not necessarily coeval.

There is an angular unconformity between the Dundas Group and the overlying Junee Group. The axes of the asymmetrical folds in the Junee Group, however, are parallel to the fold axis in the Cambrian rocks. Two miles south of Deloraine the Owen Conglomerate strikes 305° and dips at 45° to the north-east whereas the underlying Warner Siltstone strikes 295° and dips at 70° to the north-east. This outcrop of Owen Conglomerate represents the eroded northern limb of a broad anticline which is a continuation of a syncline present in the same rocks west of the Lake Highway. The northern limb of the syncline dips at 70° to the south-west and the southern limb at 45° to the north-east. To the south the conglomerate unconformably overlies the Davey Group and is almost vertical on the south-western margin of these rocks where it is folded into the Stockers Syncline.

No structural detail is available at the northern exposure of the Gordon Limestone on Cameron's property and it is concluded that the outcrop has been isolated by later (probably Tertiary) faulting. Permian and Jurassic rocks to the north have also been faulted against the Dundas Group rocks. The Gordon Limestone on Stockers Plain dips at 66° to the north-east and is apparently overturned although there is no lithological evidence for this. The Caroline Creek Sandstone conformably underlies the Gordon Limestone here and is present as a small outcrop on Stockers Plain where it lies on the axis of the Stockers Syncline.

Two major normal faults trending north-west have cut Triassic and older rocks and possibly the Jurassic dolerite in the central eastern area the downthrown blocks being to the north-east.

It is probable that these faults are post-Jurassic since distinct lineaments are visible across the Jurassic dolerite on the aerial photographs. There is no marked disjunction of the margin of the dolerite, however, and there is no conclusive evidence of faulting when examined on the ground.

A fault breccia is present on the Quamby Brook road at 877,230N-464,970E and appears to mark the position of the southernmost fault. Both of these major displacements have throws of 1200 feet. These faults have had a major role in determining the physiography of the area and are responsible for the scarp of the Great Western Tiers.

Triassic and Upper Permian rocks crop out beneath the northern margin of the dolerite sill north of the Eden Rivulet, but no sedimentary rocks occur either overlying or underlying the dolerite sill north of Exton. This either indicates that the Meander Valley was a graben or that the northern sill was intruded at a lower level and the valley floor was eroded in soft Triassic and Permian sediments. There is no field evidence for either hypothesis but it appears likely that the valley was partly controlled by the major Tertiary faulting and was later instrumental in confining the outpourings of Tertiary basalt.

A small fault is present in a creek bed at 880,850N-469,520E. The western block has been downthrown about 50 feet and Ferntree Mudstone has been faulted against Knocklofty Sandstone and Shale. The fault does not appear to disrupt the margin of the dolerite sill and may therefore be concomitant with the intrusion. On the north-western slopes of Quamby Bluff the Liffey Sandstone, which forms prominent ledges on the hill slopes, cannot be traced to the south and there is a large area here (873,000N-460,000E) covered by large dolerite blocks and dolerite, presumably in situ. A discordant sill with concomitant faulting has caused a large block of sediments to be downthrown. There is no relative displacement between Permian formations on either side of the intrusion.

The dolerite dyke which crosses the Lake Highway at 872,350N-465,300E has not displaced the Permian rocks. This intrusion may have acted as the feeder to the sill to the east which intrudes the Liffey Sandstone. The sill has not displaced the overlying beds but has probably downthrown an underlying block. The dyke strikes at 10° and crosses the Quamby Brook road at 874,230N-465,640E and continues to the north in a sill-like form and, in plan, completely surrounds an isolated outcrop of Owen Conglomerate. The dolerite was probably intruded here at the unconformity between the Permian and Lower Palaeozoic rocks.

The Quamby sill is concordant but the Cluan Sill is transgressive and dips at 4° to the north-west. The northern extensions of this sill, 5 miles south-east of Deloraine, are also transgressive. In general the dolerite is concordant where it intrudes Triassic sediments but discordant where it intrudes Permian rocks.

The regional dip of the Permian and Triassic sediments is 5° to the south-west, the strike being parallel to that of major Tertiary faults. Local dips up to 20° occur in the vicinity of major faults or close to dolerite intrusions.

## ECONOMIC GEOLOGY

Oil shale occurs in the Quamby Mudstone east of the Quamby Brook road on Bake's property.

*The Bakes Oil Shale Member is that member of the Quamby Mudstone containing abundant spores called Tasmanites punctatus, and in the type area occurring 65 feet above the base of the Quamby Mudstone. The member is 5 feet thick. It is so named because it occurs on property owned by Mr. Bakes. The type locality is in and beside Quamby Brook just upstream from the bridge carrying the road from Quamby Brook township to Golden Valley (co-ordinates 873.7N-465.8E).*

The deposit was discovered in 1919 and reported by Hills (1921) and Reid (1924). Oil shale has also been reported in the Eden Rivulet area and on Burns' property west of the Lake Highway, but both have probably been confused with the shaly carbonaceous beds in the Liffey Sandstone.

The seam is 5 feet thick and extends over an area of 310 acres which indicates a probable reserve of 1,500,000 tons of oil shale. The fresh shale is a medium-grained lutite, blue-grey on a fresh surface but weathers to rusty-brown, the spores being visible as orange-brown discs on the bedding planes. In transverse section the spores are flattened and irregular but were probably originally spheroidal or ellipsoidal.

Church (1864) applied the name "Tasmanite" to the spores which were also mentioned by Bonwick (1870) who says "The resinous dots in the dysochile have received the name Tasmanite". Newton (1875) proposed that the name Tasmanite be retained for the oil shale and that the spores be called *Tasmanites punctatus*. The origin of the spores is discussed by Singh (1931). The physical properties of the oil shale and its analysis is described by Milligan (1852), Penny (1855) and Church (1864). Research into the problems of retorting the shale and refining the products was carried out by Kurth (1933).

The oil shale at Quamby Brook originated as a small, shallow water barred basin or estuarine deposit, separated structurally from the off-shore marine Permian beds to the west by the ridges of Preambrian and Juncoc rocks. The shale has no commercial use at present, due primarily to the inferior nature of the products, but constitutes a large reserve of oil of strategic value.

Secondary azurite and malachite have been reported from the Kentish Volcanics at Quamby Brook (875,650N-465,300E) where a shaft of unknown depth has been sunk. No large deposits were observed but minor encrustations of malachite occur. No primary sulphides were observed in the lava but the oxidised zone may pass downwards into a zone of secondary enrichment and appears worthy of further investigation. Reid (1924) gives the assay of bulk samples of the ore as 0.29 per cent copper with small amounts of silver and gold.

The structure and lithology of the Dundas Group indicate conditions favourable for ore emplacement. However, the disseminated sulphides commonly found appear to be syngenetic in origin.

## SUMMARY AND CONCLUSIONS

The investigation was carried out in an area of exhumed Permian topography modified by more recent dolerite intrusions, basalt flows and Tertiary faulting. The Jurassic dolerite occupies the largest surface area.

The intricately folded quartzites and mica schists of the Precambrian Davey Group are unconformably overlain by 7000 feet of Cambrian eugeosynclinal deposits. No fossils were found in the Group but it is correlated with the Dundas Group of similar lithology and structural environment. The sediments show a large scale development of graded bedding which has been attributed to the action of high density turbidity currents. They have been isoclinally folded into an anticline, the beds dipping uniformly at about 75° to the north-east. The fold is cut by north-south trending pre-Ordovician faults. If these are normal faults, they have a throw of approximately 2000 feet.

The Cambrian Dundas Group is overlain unconformably by the folded Ordovician Junee Group rocks which are about 2300 feet thick. The fold axes in this group are parallel to those in the Cambrian rocks. It appears almost inevitable that islands of Owen Conglomerate and Davey Group existed in the Permian seas and basal Permian sediments lap against these older rocks in the Golden Valley area. The Permian sediments have suffered little deformation and the regional dip is 5° to the south. They were derived from a glaciated terrain composed of metamorphics and acid plutonics. Cyclic sedimentation is evident.

The contact between the Triassic and Permian sediments is marked by a siliceous breccia which is a prominent marker horizon. The Triassic shales have been favourable for injection by dolerite as dykes and concordant and discordant sills. All traces of sediments overlying the dolerite have been removed. Two major normal faults, probably Tertiary in age, have downthrown large blocks to the north-east and the throws, calculated from displacements in the Permian and Triassic rocks, are 1200 feet.

The extrusions of basalt are confined to the old valley of the Meander River. Eustatic fluctuations in sea level have not affected the drainage due to the presence of several local base levels in the river courses.

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## LOCALITY INDEX

Cluan	41° 39'	146° 48'
Deloraine	41° 31'	146° 40'
Exton	41° 31'	146° 45'
Golden Valley	41° 37'	146° 43'
Quamby Brook (town)	41° 35'	146° 42'
Quamby Brook (creek)	41° 33'	146° 43'
Stockers Plain	41° 36'	146° 37'